Rehabilitation of Pits and Quarries for Forest Production

Prepared for the Aggregate Resources Section,
Land Management Branch, Ontario Ministry of Natural Resources

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Part 1
Introduction

Over the years, owners of pits and quarries have planted trees to:

screen active extractions,

provide wildlife habitat,

improve site aesthetics,

reduce soil erosion, and

increase outdoor recreation potential.

Although few of these tree planting efforts were initially designed to harvest forest products, tree plantations, when properly planned and managed will produce valuable crops.

This manual is one of a series of handbooks published by the Ontario Ministry of Natural Resources (OMNR) to assist pit and quarry operators in formulating and carrying out effective rehabilitation programs. While an earlier document (Lowe, 1979) assessed trees and shrubs for rehabilitation work, this manual goes beyond that to assess forest production in exhausted pits and quarries.

In addition to guiding owners through the forest production cycle, this handbook also lists several references containing more detailed rehabilitation information. The approach and techniques presented herein are based on observations made and conclusions drawn during earlier stages of this study.

During 1987, a technical program, consisting of field and literature research, was completed. Appendix 1 contains a brief summary of that program.

***Figure 2.** Tree planting may also have a value in resource management education.*

***Figure 1.** Tree planting can encourage wildlife.*

Part 2
When Should You Consider Forest Production?

Forest production is one of several end–uses that a site owner may consider. Other alternatives are agriculture, wildlife management, outdoor recreation and residential and commercial land development.

The dry, infertile conditions found in many existing and abandoned pits and quarries are less suitable for agricultural crops than for certain commercial tree species. Tree plantations, besides being less costly to establish and maintain than agricultural crops, will provide an owner with economic benefits including:

- technical and financial assistance in planting and tending the plantation(s),
- revenue from periodic cuttings including the final harvest, and
- a 100 percent rebate on municipal property taxes for the forested portion of the property, if minimum requirements are met.

Along with those economic benefits, reforestation can reduce soil erosion, enhance wildlife habitat and improve aesthetics.

Forest production is compatible with many kinds of outdoor recreation, and on certain sites can be a profitable interim use (e.g. Christmas trees) prior to a more permanent use (e.g. residential development).

Most properties have the potential for forest production; there are, however, sites that should not be considered including the following:

- Areas less than 4 ha in size.
- Slopes steeper than 3:1 (horizontal to vertical).
- Soil depths less than 0.5 m over bedrock or a permanent water table.
- Large quarries which would require substantial amounts of fill to meet slope and soil depth conditions.
- Some areas designated as specialty cropland (portions of the Counties of Essex, Grey, Kent and the Niagara Region) and agriculture land classes 1–3. Approval may be required from the Ontario Ministry of Agriculture and Food.
- Land slated for development as industrial, commercial or residential property in the foreseeable future. Long term projections of when parcels will be converted to urban use are difficult to make. Generally, the closer to an urban centre, the more unlikely an end–use, forest production will be.

***Figure 3.** A managed woodlot may allow the property owner a total rebate of municipal property taxes.*

Part 3
Five Steps To Successful Reforestation

The planning and rehabilitation stages are basically the same for both pits and quarries. Any differences are explained in each of the five steps.

1. Planning
2. Site Preparation
3. Tree Planting
4. Tending
5. Marketing/Harvesting

These steps are illustrated in Figure 4.

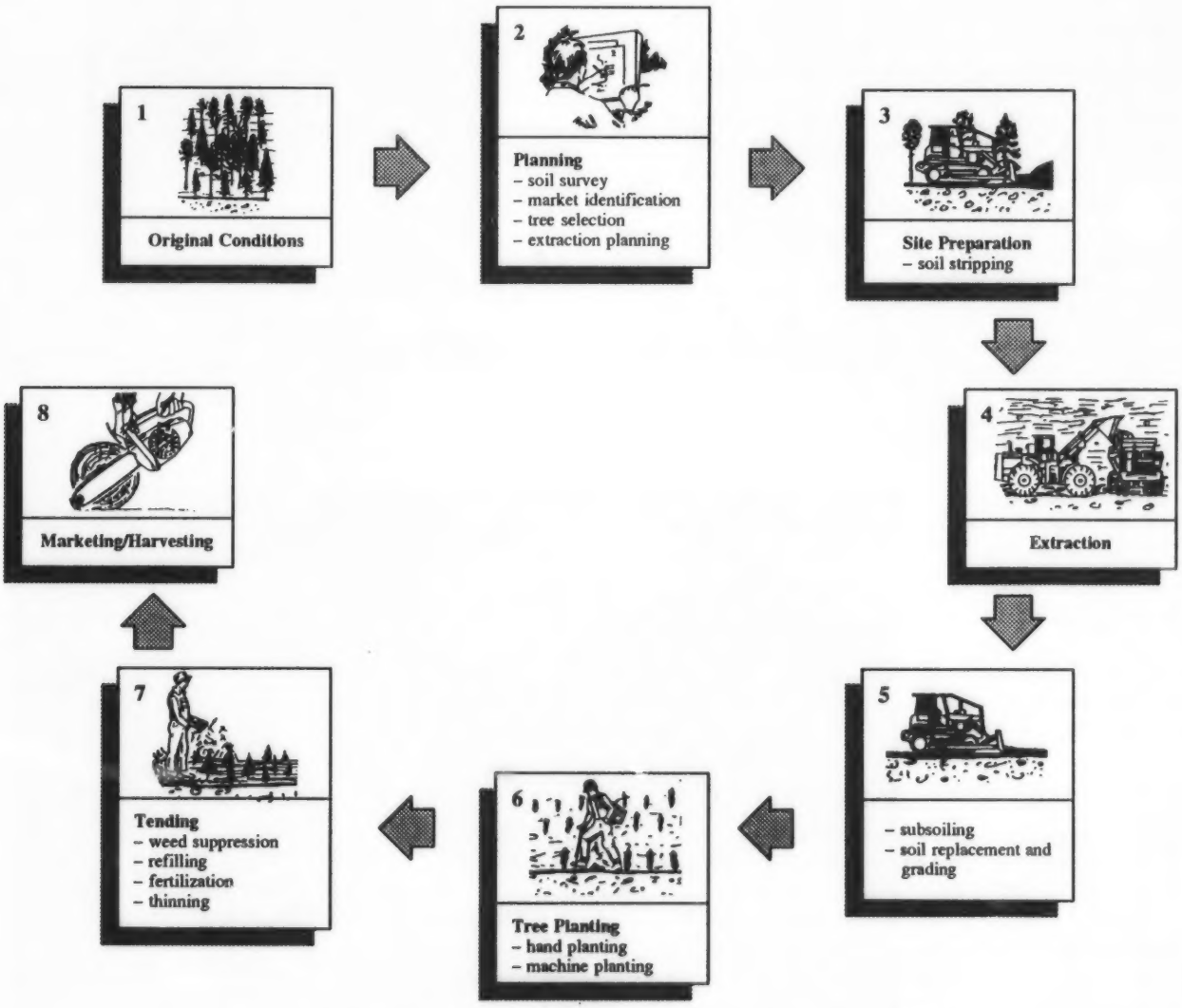


Figure 4. Reforestation planning sequence (after Miller and Mackintosh, 1987).

STEP ONE: PLANNING

Forest production may be suited to abandoned, existing and future extraction operations. Planning begins before the extraction stage on proposed sites because certain extraction steps will influence the site's ability to produce a tree crop. Many of the same planning elements can be applied after some or all of the extraction has been completed.

The four main planning elements are:

- soil survey,
- market identification
- tree selection, and
- extraction planning.

Soil Survey

An understanding of the soils and underlying materials is essential to successful rehabilitation. Prior to extraction those soils should be carefully examined to determine characteristics and suitability for stripping, stockpiling and later re–using.

The soil is composed of distinct layers or horizons, recognized by differences in colour and form. While it takes a trained investigator to precisely define soil types, an owner can gain a basic understanding by examining a soil profile.

A profile may be viewed at exposed areas (road cuts, side hills, etc.) or by digging a small pit (1 m deep).

The three common layers in the surface material are topsoil, subsoil and overburden. Some characteristics of each are described.

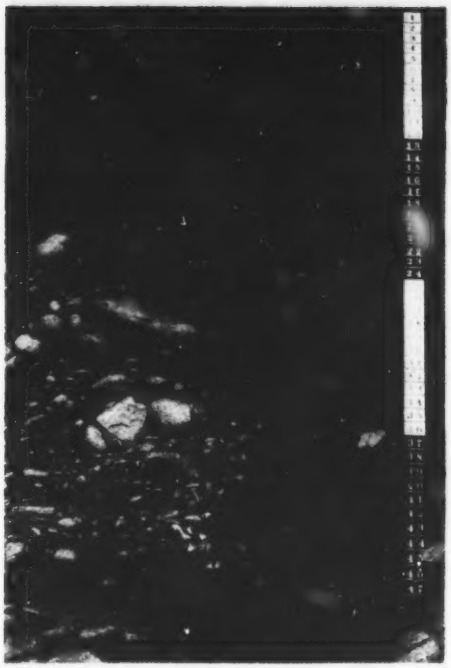


Figure 6. *A soil survey will help determine the appropriate tree species to plant.*

Figure 5. *Successful pit reforestation begins with proper site planning.*

Topsoil

This surface layer is characterized by a dark colour (relative to underlying materials), caused by an accumulation of organic matter. It is often overlain by a few centimetres of decaying organic matter (e.g. leaves, dead plants). This layer is the most critical component of the growing medium, and is often missing or very thin on properties slated for rehabilitation.

Subsoil

Immediately below the topsoil, this mineral soil layer is found. It is the second most important layer for vegetation growth. Plants obtain both nutrients and moisture from this zone. It often has some accumulation of clay, organic matter and certain micronutrients.

Overburden

This term refers to material between the extractable deposit and the subsoil. It is not technically referred to as soil and is often missing in Ontario deposits. The presence of this material greatly enhances forest production potential.

Each layer should be examined for texture, colour, depth and moisture. Healthy, dense vegetative growth can suggest the presence of adequate moisture and nutrients. The three major nutrients are nitrogen, phosphorus and potassium. Sparse growth suggests a dry and infertile site.

Market Identification

Since tree plantations can produce a variety of products, it is advisable to identify and locate primary and secondary wood using industries such as sawmills, pulp mills, pallet plants, pole producing plants and specialty plants.

There are about 40 pulp and paper mills in the province. Half are located in the north. Those are the primary mills which purchase raw materials for production. Most of the remaining mills, scattered throughout southern Ontario, rely primarily upon pre–processed material from northern mills.

Approximately 100 lumber producing sawmills are scattered relatively evenly throughout the province. Many are small mills serving local southern and central Ontario markets.

Advice regarding where to market products is available from district OMNR forestry staff. Mills are also listed in Cater (1988) and Mullunder (1987).

Tree Selection

The tree species selected will depend on planting site conditions and available markets. If more than one species is suitable, then owner preference may dictate which will be planted.

Nursery stock is available from ten OMNR nurseries (see Appendix 2 for locations) and from privately owned nurseries. Private nurseries can generally offer a more varied range of species. Many however, are produced in smaller quantities and are not available in seedling size. To ensure delivery, seedling orders should be placed during the summer, the year prior to proposed planting.

An approach is provided to allow owners to select potential trees for planting. It is based upon three basic types of site and is meant to provide a general guideline. The three have been distinguished based upon differences in soil layer depths and moisture. They are average characteristics identifiable from a general familiarity with conditions across the site.

SITE TYPE IDENTIFICATION/SPECIES SELECTION

Combined depth of topsoil and subsoil (m)	Surface soil moisture	Site type
0–0.5	dry	harsh
0.5–1.0	dry–moist	moderate
1.0+	moist	preferred

More details regarding common site characteristics are included with tree species recommendations Tables 1 to 6: two tables for each site type. Generally, the species to select from are more limited on harsh sites than on moderate and preferred sites. The site location will influence tree selection. The designations; Boreal, Great Lakes – St. Lawrence, Deciduous are described in Appendix 3.

Minor differences in soils, moisture, topography and climate can affect tree species selection. Appendix 3 provides more detail about the characteristics of the trees recommended for rehabilitation. Advice for confirmation of species can also be obtained from the OMNR district personnel.

Extraction Planning

Planning when undertaken at the outset, can increase the efficiency of extraction and provide for a very desirable end– use. The planning requires a complete understanding of the site conditions prior to extraction, the sequence of operations and how the site will finally appear.

The sequence of extraction and the locations of soil stockpiling are important. As a section of the site is exhausted, soil replacement and grading can be completed to prepare that area for planting.

The final contours of the site affecting slope and drainage, must be known at the outset. Of use are cross–sections prepared for the completed site showing grades and cover material depth. A basic approach to rehabilitation can then be formulated.

The careful planning of the rehabilitation program can result in considerable savings of time and money. It allows the owner to take advantage of available personnel and equipment for both extraction and rehabilitation.

TABLE 1. HARSH SITE CHARACTERISTICS.

Soils Description	
topsoil: / subsoil:	combined depth 0 to 0.5 m with topsoil layer almost absent
overburden:	usually very limited or lacking
fertility:	low
Drainage:	well drained creating dry to droughty conditions
Water Table:	deep, generally more than 3 m below final grade

Comments:

Situation often encountered in northern Ontario, particularly north central and northwestern regions (Miller and Mackintosh, 1987). A common situation on abandoned sites or operating sites where topsoil has not been retained.

TABLE 2. TREE SPECIES SELECTION – HARSH SITES.

Forest Region	Primary Timber Species	Secondary Specialty Species
Boreal	*Jack Pine* (Trembling Aspen)	(White Birch) (Pin Cherry)
Great Lakes – St. Lawrence	*European Larch* (Trembling Aspen)	Black Locust (White Birch) (Eastern Red Cedar)
Deciduous	*Red Pine* *European Larch* (Trembling Aspen) (Black Oak)	(Chinquapin Oak) (Chestnut Oak) (Pignut Hickory) (Pitch Pine) Black Locust (White Birch) (Eastern Red Cedar)

Notes:

Preferred species are indicated in italics.

Species limited by uncertain availability are enclosed in parentheses.

Hardwood species (e.g. oaks) are more difficult to establish. Those listed here are suited to pit and quarry conditions but may require more intensive maintenance.

TABLE 3. MODERATE SITE CHARACTERISTICS.

Soils Description	
topsoil: / subsoil:	combined depth between 0.5 and 1 m. Topsoil component usually less than 0.3 m
overburden:	present, but generally limited to less than 0.5 m
fertility:	moderate
Drainage:	well drained but less prone to dry, droughty conditions, owing to greater presence of organic matter
Water Table:	2 to 3 m below final grade

Comments:

More commonly encountered in southern Ontario situations.

TABLE 4. TREE SPECIES SELECTION – MODERATE SITES.

Forest Region	Primary Timber Species	Secondary Specialty Species
Boreal	*Jack Pine* *White Spruce* Eastern White Cedar Black Spruce (Trembling Aspen)	(White Birch) (Pine Cherry)
Great Lakes – St. Lawrence	*Red Pine* *European Larch* *White Spruce* *Eastern White Pine* Eastern White Cedar Norway Spruce Black Spruce (Trembling Aspen)	(White Birch) (Eastern Red Cedar) (Chinquapin Oak) (Chestnut Oak) (Pignut Hickory) (Pitch Pine) (White Birch) (Eastern Red Cedar)
Deciduous	*Red Pine* *European Larch* *White Spruce* *Eastern White Pine* Eastern White Cedar Norway Spruce (Black Oak) (Trembling Aspen)	

Notes:

Preferred species are indicated in italics.

Species likely limited by uncertain availability are enclosed in parentheses.

Hardwood species (e.g. oaks) are more difficult to establish. Those listed here are suited to pit and quarry conditions but may require more intensive maintenance.

TABLE 5. PREFERRED SITE CHARACTERISTICS.

Soils Description	
topsoil: / subsoil:	combined depth greater than 1.0 m
overburden:	present often at depths greater than 0.5 m
fertility:	moderate to high
Drainage:	well–drained and moist, not prone to droughtiness
Water Table:	1 to 2 m below final grade
Comments:	
These conditions are rarely encountered in rehabilitated sites. These sites allow introduction of higher quality hardwood species; Red Oak and White Ash.	

TABLE 6. TREE SPECIES SELECTION – PREFERRED SITES.

Forest Region	Primary Timber Species	Secondary Specialty Species
Boreal	*Jack Pine*	
	White Spruce	(White Birch)
	Eastern White Cedar	(Pin Cherry)
	Black Spruce	
	(Trembling Aspen)	
Great Lakes – St. Lawrence	*Red Pine*	
	Eastern White Pine	
	White Spruce	
	White Ash	(White Birch)
	Red Oak	
	Silver Maple	
	Red Maple	
	Eastern White Cedar	
	Norway Spruce	
	(Trembling Aspen)	
Deciduous	*Red Pine*	
	Eastern White Pine	
	White Spruce	
	White Ash	
	Red Oak	
	Silver Maple	(White Birch)
	Red Maple	
	Eastern White Cedar	
	Norway Spruce	
	(Trembling Aspen)	

- *Notes:*
  - *Preferred species are indicated in italics.*
  - *Species likely limited by uncertain availability are enclosed in parentheses.*
  - *Hardwood species (e.g. oaks) are more difficult to establish. Those listed here are suited to pit and quarry conditions but may require more intensive maintenance.*

STEP TWO: SITE PREPARATION

The preparation of a site for planting includes three main steps:

- soil stripping (prior to extraction),
- subsoiling and
- soil replacement and grading (after extraction).

Soil Stripping

Topsoil, subsoil and overburden should be stripped from a site using a bulldozer or scraper during dry weather. Topsoil and subsoil should be piled separately from overburden in low mounds to prevent mixing and compaction. Large mounds of soil create conditions that deplete nutrients and reduce necessary microbial activity. Care should also be taken to avoid running heavy equipment over the soil stockpiles. If the soil materials are to be stockpiled for more than one growing season, they should be seeded with grasses to control erosion. The stockpiling can provide temporary berms for the property perimeter.

Subsoiling

On sites where heavy equipment has compacted the material on the pit floor, the compacted layer should be ripped to a depth of at least half a metre, the depth which will accommodate the majority of moisture and nutrient–seeking tree roots. If no ripping equipment is available, deep plowing is beneficial. In general terms, the deeper and more intensively a site is cultivated, the better the trees will grow. Deep tillage should be done prior to other post extraction activities. Consideration should be given to two ripping passes over the site. The two passes should be completed at right angles.

Soil Replacement and Grading

Where no grading is required, the soil layers should be replaced in the same order as they were prior to stripping. Where grading is necessary, the overburden should be used and the subsoil and topsoil reserved for the final layer.

Grading is often necessary to reduce the final slopes, enhance drainage and to provide access for tree planting, tending and harvesting equipment. Slopes should be no greater than 3:1 (horizontal to vertical).

Two special cases requiring modifications to common grading techniques follow.

1. high water table:

   Where the water table is encountered at or near the pit floor surface, a planting ridge or mound must be created. Ridges between 1 and 2 m high and 10 to 20 metres wide should be established and the seedlings placed on the top. These ridges will reduce flooding of seedlings at times of a high water table. Large ridges will also reduce the possibility of desiccation, likely on smaller earth mounds, during dry periods of the growing season.

2. scarcity of topsoil:

   A limited amount of topsoil can be placed selectively in bands where planting will occur rather than across the entire site.

***Figure 7.** Where possible, topsoil and subsoil are stored separately, then replaced in order after the final pit contours are established.*

***Figure 8.** Topsoil is spread and levelled with a minimum amount of handling to reduce soil compaction.*

Upon completion of grading, the site is ready for tree planting. Because grasses and herbaceous plants compete with tree seedlings for moisture and nutrients, it is preferable to plant on a bare soil.

Where soil erosion is a concern, it may be desirable to include a cover crop of grasses and legumes between tree rows. It is however, important that the cover crop be suppressed in the immediate vicinity (0.5 m) of each tree stem to limit competition.

Common grasses and legumes suited to such a purpose include: Canada Bluegrass (*Poa compressa*), Timothy (*Phleum pratense*), Perrenial Ryegrass (*Lolium perenne*), Alfalfa (*Medicago sativa*) and Red Clover (*Trifolium pratense*). Legumes fix nitrogen in the soil, thus increasing the availability of that nutrient for nearby plants. Black Locust is also a legume and can be planted in a mix with other tree species to enhance growth.

STEP THREE: TREE PLANTING

A major consideration in tree planting is to minimize the time between tree acquisition and planting. At no time during this period should the roots become dry. If the seedlings cannot be planted immediately, they should be kept in a cool, moist condition, either by heeling them in or keeping them in a cool storage shed.

Heeling in, refers to putting the seedlings in a "V" shaped trench and packing the roots with moist earth. The trench should be in a shaded location.

If the seedlings are coniferous, they will be received in sealed bags which should not be opened until the trees are to be planted. The hardwood seedlings are too large for the bags and arrive in burlapped bundles. It will be necessary to water the hardwood stock awaiting planting.

Only bare root stock should be considered for planting. In situations where it is possible to specify the age of seedlings, there should be a preference for 2 year old stock. Exceptions to this are some fast growing hardwoods (e.g. Black Locust and Poplar) which are available as 1 year old stock and some slow–growing conifers (e.g. White Cedar and White Spruce) which are available as 3 or 4 year old stock.

It is not necessary to plant areas smaller than 10 ha with more than one species, except where very specific soil and moisture conditions require. Larger sites are best planted in a mix of species. This will reduce the possibility of the entire plantation being seriously damaged or destroyed by insects or disease. The compatibility of species within the plantation for growth and harvest purposes, should be considered. It becomes less feasible economically to plant, tend and harvest plantations smaller than 4 ha.

On larger sites firebreaks, which double as access roads through and around the plantation, should be included. These can be between 3 and 5 m wide and are most effective when situated at right angles to the prevailing winds. These access roads should be maintained through the life of the plantation.

Two planting methods are discussed; hand planting and machine planting.

Hand Planting

Two techniques are recommended for hand planting; the wedge and hole methods. The wedge method is described and depicted in Figure 9. The hole method consists of the following steps.

- Dig a hole large enough to accommodate the roots without cramping them.
- Place the seedling in the hole and spread the roots. The seedling should be planted with the root collar (bulge) at ground level.
- Replace the soil, tamping it firmly to avoid air pockets. Discard any turf.

Hand planting is more time–consuming than machine planting but usually results in greater survival.

Machine Planting

Planting trees by machine is practical only on areas larger than 4 ha. With a qualified operator, the planting cost is about half that

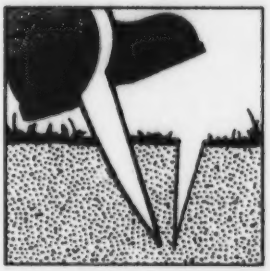
Figure 9. Wedge method of hand–planting.

1

Tramp shovel straight down into soil with back of shovel away from you

2

Make sloping cut with back of shovel towards you.



3

Remove wedge of soil if necessary, dig the hole deeper to accommodate roots without bunching. Place tree in hole with roots against vertical face.

4

Return wedge. Tramp soil around tree with your heel.

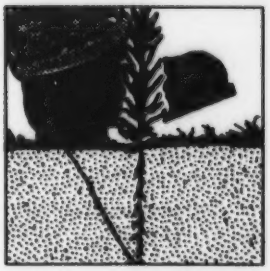


Figure 10. Machine planting is cost effective when the area to be planted is larger than 4 ha.

Figure 11. On small pits or pits with long or steep slopes, hand planting is the most effective method.

of hand planting. Tree planting machines can sometimes be rented from a conservation authority or the OMNR. Private tree planting companies also provide services in most of Ontario.

Other aspects of planting to consider are; timing, spacing and orientation.

At one time, tree seedlings were available for spring and fall planting, but experience has shown that spring planting is more successful. Therefore, planting should be done in the spring as soon as the ground is frost–free. This varies from late March to early April in southwestern Ontario and late May in some parts of northern Ontario.

Standard spacing for planting most tree species is 2.1 m between rows and 1.8 m within rows. This spacing represents 2,454 trees per ha and permits equipment to move between rows without damaging the seedlings. The direction of the rows should be such that there is easy access from roads.

STEP FOUR : TENDING

Tending includes any maintenance required after planting and before harvesting such as weed suppression, pest control, refilling, fertilization, thinning and pruning.

Weed Suppression

During the first three or four years after planting, competing vegetation (e.g. grasses, weeds) should be kept clear for at least 0.5 m from the tree stem. This can best be done by spraying herbicides around the tree as soon after planting as possible. If the trees are machine planted, herbicides can be applied in the same operation.

Since there are a number of approved herbicides available, and licensing requirements for application, it is advisable to obtain recommendations and assistance from qualified and licensed operators. Dosages will vary with the tree species, competing vegetation and the soil type. Some guidelines are presented by the Ministry of Agriculture and Food (1987). One application of a herbicide, such as simazine, can reduce weed competition on some sites for at least two growing seasons.

On smaller areas a backpack sprayer can be used. Larger areas may require power sprayers mounted on a wheeled vehicle. Mowing is not considered to be as effective as spraying for weed control.

Pest Control

Insects and disease can pose problems for plantation growth. Because of the abundance of pest species, it is impossible to discuss the characteristics and effects of each, in this manual. Symptoms of pests such as defoliation, wilting, discoloration or mortality should be identified and treated. Advice is available from the OMNR district personnel.

Other pests such as rodents can cause high tree mortality. They can be controlled by eliminating weeds from around tree stems and by the use of zinc phosphide in reforested areas.

Refilling

Inevitably there will be some mortality in plantations. During the second and third seasons, inspections should be completed to assess losses.

Where mortality is greater than 20 percent, replacement seedlings should be planted.

Fertilization

Planting sites are usually deficient in some of the 20 nutrients required by trees for healthy growth. The macronutrients; nitrogen, phosphorus, potassium, calcium, magnesium and sulphur are the most important.

Fertilizer application is not recommended before or during planting. Seedlings fresh from the tree nursery do not possess adequate root systems to take full advantage of the supplemental nutrients. Rather, weeds which germinate shortly after site preparation will be the recipients of such benefits.

Figure 12. Insects and disease can be controlled by spraying.

After the trees have been established for 4 or 5 years, they may exhibit symptoms of nutrient deficiency. Those symptoms will vary depending upon the tree species and the nutrient lacking. Assistance is provided by the OMNR in assessing plantation health and determining fertilization requirements.

In addition to that service, the owner can collect samples of twigs and foliage from a number of representative trees across a site and submit them for analyses. A lab can determine very accurately, the fertilization requirements for existing nursery stock and provide specific recommendations (see Part 6, nutrient testing).

Costs can be reduced by applying fertilizer on rows of affected trees rather than a broadcast application.

Thinning

Periodic thinning in a plantation is necessary to maintain a proper growth rate. In the early thinnings, sometimes called "cleanings", trees of poor form or growth are removed. As the general health of the stand is improved, with each successive thinning, the criterion used to select trees for removal will be their interference with the growth of the selected "crop trees". The crop trees are chosen in the early stages of the plantation based on form, growth and spacing.

***Figure 14.** Thinning and pruning of the plantation will allow the strongest trees to grow to their fullest extent.*

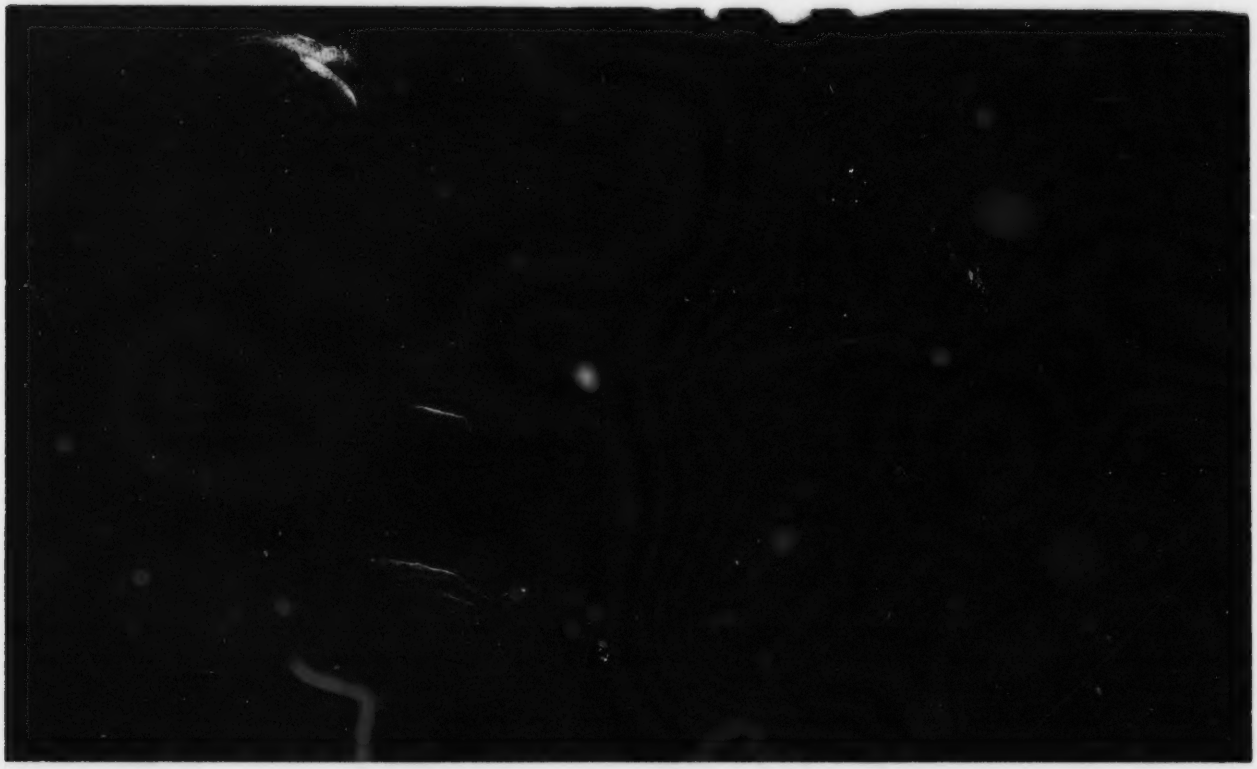


***Figure 13.** Inspections should be performed during the second and third growing seasons to determine the health of the plantation.*

STEP FIVE: MARKETING/HARVESTING

In a well–managed tree plantation, forest products can be marketed from the first or second thinning until the final harvest of the remaining trees.

Some general management guidelines are provided based on time periods throughout the production cycle of the plantation. Since thinning operations will vary with tree species and site and market conditions, no hard and fast rules are practical. Because most plantations are coniferous, these guidelines do not include hardwoods or specialty crops such as Christmas trees or hybrid poplar.

0–5 years

Little work is required beyond the tasks outlined in Step Four. The plantation should be protected from fire and livestock grazing and examined periodically for diseases and insects. The OMNR can provide identification and remediation services.

5–30 years

When the crowns of the trees begin to close, near years 25–30 years for most sites, it is time to remove every fourth row of trees. This allows access of equipment for future tree removal and for fire protection. This thinning may offer products for sale such as pickets,pulpwood chips, etc.

30–35 years

Early in this period the crop trees could be selected and marked. The owner of a White Pine plantation should also prune the branches halfway up (approximately 5 m) the crop trees. Pruning acts to increase log volume and to provide knot–free material. It can therefore also increase the value of the product. Red Pine is considered to be self–pruning.

Since periodic thinning approximately every 5–7 years maintains good growth, the second thinning could be made at 30–35 years. At this time approximately one third of the plantation could be cut. Trees of poor form and growth should be marked for removal. This will reduce the stand to 1205 trees per ha. The forest products will be pulpwood, boltwood, posts and chips.

30–70 years

Trees to be removed will be those that are competing with the crop trees.

Thinning can be considered at 5–7 year intervals, with a final harvest between years 60–70 for Red Pine and year 100 for White Pine. Harvest age depends upon species grown and products desired. Operations between ages 35 and 65 should remove between 20% and 25% of the material. By age 45, the first quality poles should be produced. Each thinning yields larger, higher quality products.

Final Harvest–60 years +

The final harvest should yield both poles and some sawlogs. By this point there will be approximately 75 to 100 trees per hectare. The harvest date will depend upon species and product desired. Throughout the thinning and harvest operations, there is some flexibility to target products to take advantage of better market conditions.

While pit and quarry operators may be able to determine the kinds of products their plantation can grow, they would benefit from consultation with OMNR personnel who are aware of current market conditions and potential trends in demand for forest products. Examples of typical forest products are outlined in Table 7.

TABLE 7. SUMMARY OF TYPICAL FOREST PRODUCTS.

Product	Size Requirements		End–use	Suggested Species
	diameter (cm)	length (m)		
Boltwood	20	1.2 – 2.4	wooden pallets, landscape squares	red pine, white spruce
Pulpwood	20 +	2.4	paper products	white spruce, jack pine, hardwoods
Chipwood	8 +		paper products, bedding material	white spruce
Polewood	30 +	variable	telephone and utility poles	red pine, jack pine
Sawlogs	36 +	5 +	construction, furniture, specialty products	white pine, white spruce, jack pine
Veneerlogs	variable	variable	furniture, baskets, matches, specialty products	white pine

Note: Most trees planted for pit and quarry rehabilitation will be coniferous. Products in this table refer therefore, only to coniferous material. Several deciduous species do have potential for use as rehabilitation material. Guidance for planting those more demanding trees is available from the OMNR.

Part 4
Economics

The potential revenue to be gained through forest production will contribute to the selection of this end–use. The following data (Tables 8 and 9) provide a general indication of the costs and revenues involved. They are based upon 1988 dollars and are approximate ranges.

The revenue table is based upon a sample Red Pine plantation. That species is one of those suggested as preferred in all three forest regions (Part 3), and is the most commonly planted. Costs and revenues for other species differ. Details can be gained from OMNR district personnel.

Red Pine growth tables (Beckwith et al., 1983) for a site class similar to common pit and quarry conditions, were used to estimate revenues.

Table 8 shows that an owner would spend approximately $3,500.00 to reforest a 10 ha site, while revenues (Table 9) generated over the long term would total $17,000.00. As well, all municipal property taxes on the reforested portion of the area could be rebated.

All costs and revenues will depend upon site size, location, market conditions and the quality and species of tree planted.

TABLE 8. PLANTATION ESTABLISHMENT AND TENDING COSTS.

Task		Cost per hectare ($)
Planting		
trees		125
hand planting		50 to 75
machine planting		25 to 50
	total planting cost:	[1] 150 to 175
Weed suppression		
backpack equipment or mobile equipment (to be completed at outset and in year 3)		100 to 150
	total weed suppression cost	[2] 200 to 300
Thinning		[3] 0
Pruning		
to be completed at year 25		[4] optional (500)
Harvesting		[3] 0
	Total Establishment/Tending Costs 350.00 to 475.00 without pruning	

Notes:

1. *Planting costs depend upon method used. For purposes of this table, it was assumed that trees were machine planted.*
2. *Variable costs for pest control, refilling and fertilization not included.*
3. *This assumes products are sold "standing" (crop is sold in place and buyer completes harvest).*
4. *Pruning will provide increased revenues over the production cycle. Its use is dependent upon tree species, site conditions and market.*

TABLE 9. PLANTATION REVENUES BY PRODUCTION CYCLE.

Point in production cycle (years)	Potential revenue per hectare ($)
0–5	nil
5–30	nil
30	100
36	100
42	150
48	150
54	150
60	150
66	200
72 (final harvest)	700
Total potential revenue over the production cycle (per hectare)	$1700.00

Note:

This is based upon basic establishment and tending costs listed in Table 2 (without pruning).

Thinning is recommended after every 5–7 year period. Revenue generation for this table based on a thinning every 6 years after year 30, with a final harvest at year 72.

Part 5
What The Law Requires

Owners of pits and quarries are subject to a number of Provincial statutes, policies and guidelines designed to ensure an effective extraction and rehabilitation operation.

Three statutes and one policy statement pertinent to forest production and rehabilitation, are described. Other statutes which can influence extraction operations more generally are also listed.

• PITS AND QUARRIES CONTROL ACT

This legislation regulates private pit and quarry operations in designated areas which occur in most of southern Ontario as well as the region around Sudbury and Sault Ste. Marie. The Act dictates that prior to aggregate removal, a site plan must be approved which includes details of extraction and rehabilitation operations.

The purpose of this Act is to minimize adverse environmental and social impacts of aggregate operations while maintaining the viability of the industry to meet the local, regional and provincial demand for aggregates.

• MINING ACT

This Act requires that a quarry permit be obtained prior to the removal of sand and gravel from Crown land.

The permit may also contain provision for the rehabilitation of the extraction site.

• MINERAL AGGREGATE RESOURCES POLICY STATEMENT

This provincial policy, under Section 3 of the Planning Act, provides direction for municipal planning with respect to mineral aggregate resources.

It contains information instructing the Ministry of Natural Resources to encourage mineral aggregate extraction as an interim land use. That extraction is to be encouraged sequentially in a manner compatible with surrounding land uses. Official plans may require rehabilitation of all extraction sites to suitable end uses.

• WOODLANDS IMPROVEMENT ACT

Landowners may be eligible for assistance, technically and financially, under the Woodlands Improvement Act (WIA).

Woodlands Improvement Act agreements include:

- tree planting,
- stand improvement advice (e.g., tree marking),
- advertisement of products for sale,
- improvement thinning and
- advice for forest fire protection, insect and disease problem– solving and wildlife habitat improvement.

Some conditions of a landowner's eligibility for a WIA agreement follow.

- A minimum of 2 ha and a maximum of 810 ha of land is required.
- The operator is responsible for the purchase of trees.
- A 15 year commitment to the agreement is necessary.

Any landowner, regardless of property size is eligible for limited advisory services without charge. They are outlined in Part 6.

Several other Acts and guidelines influence the licensing and operation of pits and quarries. They include:

Conservation Authorities Act,

Municipal Act,

Environmental Protection Act,

Ontario Water Resources Act,

Occupational Health and Safety Act,

Pesticide Control Act,

Beach Protection Act,

Lakes and Rivers Improvement Act,

Planning Act, and

Foodland Guidelines.

Part 6
Where To Turn For Assistance

• MINISTRY OF NATURAL RESOURCES

A wide variety of advisory activities are offered under the OMNR's Private Land Forestry program.

Forest management staff at the district level, provide:

field inspections and technical advice,

planting and woodlot management plans,

prescriptions for improvement or harvest cutting,

tree marking service,

assistance in the identification of markets and the sale of forest products,

advice on protection from fire, insects, disease and livestock and

recommendations for integrated resource management (e.g., wildlife, recreation, aesthetics).

In this program, tree planting and woodlot improvement operations are the responsibility of the landowner.

There is also financial assistance available to operators who are eligible landowners under the Ontario Managed Forest Tax Rebate Program.

This program provides an incentive to manage forested property productively. It provides a 100% rebate of property taxes for all lands being managed for forestry. Eligible landowners are those who:

- are Canadian citizens or permanent residents,
- meet density and species requirements,
- have a WIA agreement or a plan Certified by a Registered Professional Forester or,
- own more than 10 ha.

The Managed Forest Tax Rebate Program is the responsibility of the OMNR and the Ministry of Municipal Affairs.

More details are available from:

Subsidies Branch
Ministry of Municipal Affairs
777 Bay Street
Toronto, Ontario
M5G 2E5

Addresses and telephone numbers of OMNR district offices are provided in Appendix 4. They are the primary sources of advice and information for operators interested in forest production.

• CONSERVATION AUTHORITIES

In many areas, conservation authorities establish and undertake programs to further conservation, restoration, development and management of natural resources. Some conservation authorities provide a source of technical advice and tree seedling stock. Appendix 6 lists conservation authority offices.

• NUTRIENT TESTING

Agri–Food Laboratories in Guelph provide a free soil testing service for phosphorus, potassium, calcium and magnesium. Based upon soils analyses, soil amendment recommendations for both existing and proposed nursery stock, can be provided.

Agri–Food Laboratories
Unit 1
503 Imperial Road
Guelph, Ontario
N1H 6T9
(519) 837–1600

Nitrogen and plant tissue analyses are available for a nominal cost. Tissue analyses after tree establishment, are preferred to soil analyses when determining fertilizer requirements.

Part 7
Summary

Forest production is a viable end–use on most pit and quarry sites in Ontario. Urban land pressures and agricultural requirements may preclude it from portions of southern Ontario.

The techniques for rehabilitation for pits differ little from those required on quarries once certain grades are established. Generally, however, quarries require more fill to establish both proper grades and planting bed. They therefore cost more to prepare for reforestation.

The key rehabilitation steps include planning, site preparation, tree planting, tending and marketing and harvesting crops.

A range of technical assistance is available, primarily through OMNR district offices. Financial incentives include government subsidized tree seedlings, 100 percent rebates on municipal taxes and revenue from the production of valuable forest products.

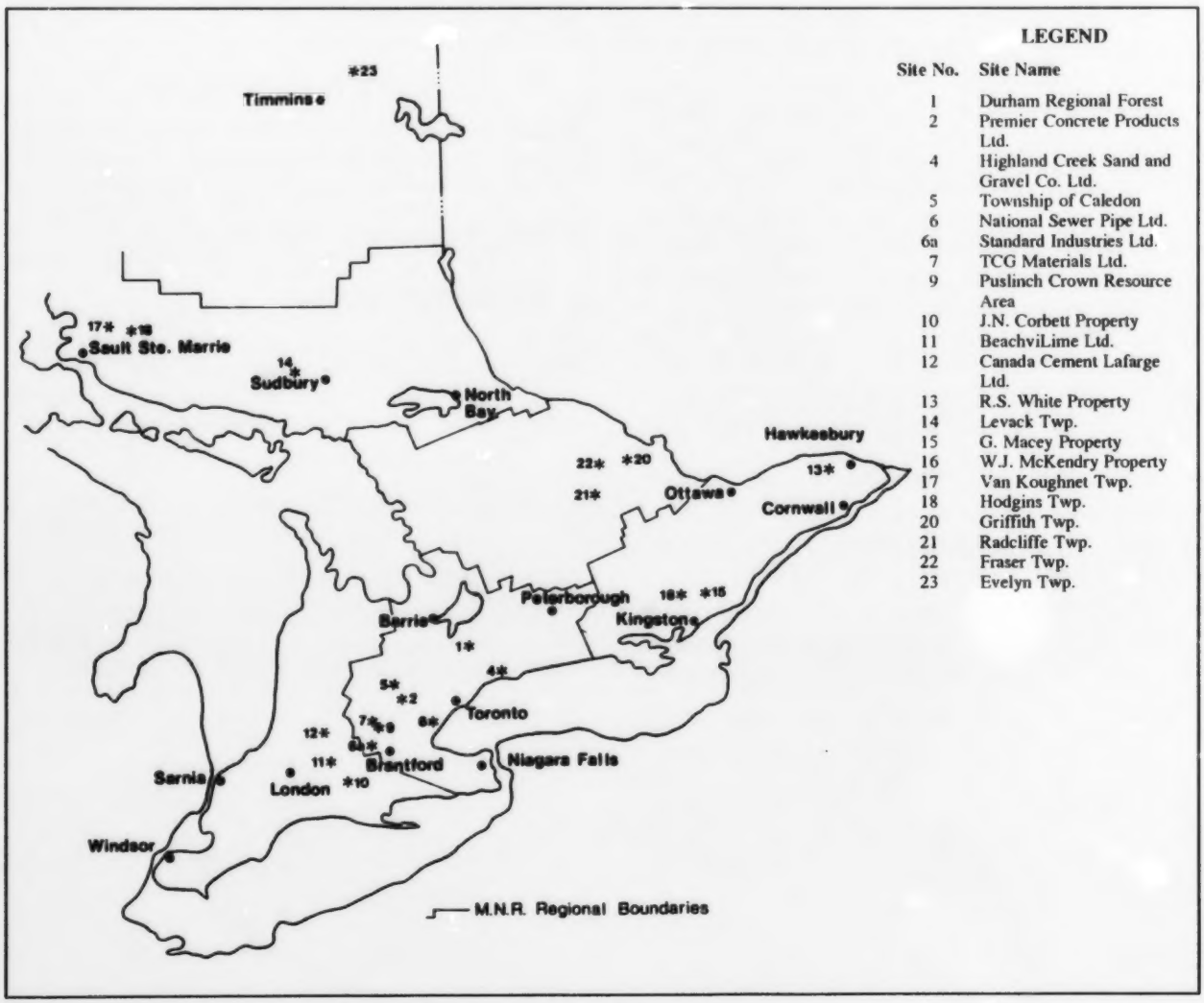


Figure 15. Site investigations maps.

Appendix 1
Summary Of Technical Study

This study was undertaken to determine the potential of exhausted pits and quarries to support productive forestry operations. The four objectives established were to:

- evaluate existing attempts to rehabilitate pits and quarries to forest production,
- gather and document sources of advice available to the aggregate industry,
- identify preferred reforestation methods and
- produce a practical reference manual.

At the outset of the technical program, a list of approximately 60 example sites was compiled from OMNR district offices across the province. Criteria were developed to select sites that would be appropriate for field investigations.

Fieldwork was completed at 21 locations ranging from Timmins to Tillsonburg to Hawkesbury. Figure 15 depicts those sites and Table 10 provides detailed locational data. Data were gathered regarding site topography, soils, drainage and reforestation success. Details of field assessments are available in the background technical report.

Literature review, in conjunction with field data results, provided an evaluation of the best reforestation techniques for pit and quarry rehabilitation. Those techniques are presented in a practical manner in this manual.

TABLE 10. FIELD INVESTIGATION SITES.

OMNR District	Site #	Site Name	Township	Lot	Conc.(s)
Maple	1	Durham Regional Forest Main Tract – 48A	Township of Uxbridge	11,12	8
Maple	2	Premier Concrete Products Limited	Town of Caledon	17–20	3
Maple	4	Highland Creek Sand and Gravel Co. Ltd., Brougham Property	Town of Pickering	13	5
Maple	5	Caledon Township Pit	Town of Caledon	15	3
Cambridge	6	National Sewer Pipe Ltd.	Town of Flamborough	1–3	2
Cambridge	6a	Standard Industries Ltd.	Township of South Dumfries	25,26	1
Cambridge	7	TCG Materials Ltd.	Township of Puslinch	23–25 26, 27	7 2
Cambridge	9	Puslinch Crown Resource Management Area	Township of Puslinch	6–8	2
Aylmer	10	J.N. Corbett Property	Township of South West Oxford	Part Lots 26–28	6
Aylmer	11	BeachviLime Ltd.	Township of Zorra	17,18	1–3
Aylmer	12	Canada Cement Lafarge Ltd.	Township of Zorra	1	4
Cornwall	13	R.S. White Property	Township of Locheil	10	9
Sudbury	14	Levack Twp. Site	Township of Levack	Unsurveyed Twp.	
Napanee	15	G. Macey Property	Township of Pittsburgh	31	7
Napanee	16	W.J. McKendry Property	Township of Kingston	30,31	6
Sault Ste. Marie	17	VanKoughnet Township Pit	Township of VanKoughnet	NE 1/4	Section 37
Sault Ste. Marie	18	Hodgins Township Pit	Township of Hodgins	2	4
Pembroke	20	Griffith Township Pit	Township of Griffith	Unsurveyed Twp.	
Pembroke	21	Radcliffe Township Pit	Township of Radcliffe	5	11
Pembroke	22	Fraser Township Pit	Township of Fraser	21,22	9
Timmins	23	Evelyn Township Pit	Township of Evelyn	2	1

** Site # 3, 8 and 19 not investigated due to lack of background information*

Appendix 2
Tree Nurseries

Ontario Government Tree Nurseries

CHAPLEAU
190 Cherry Street
Chapleau, Ontario
P0M 1K0
(705)864–1710

GOGAMA
Gogama, Ontario
P0M 1W0
(705)894–2000

KEMPTVILLE
G. Howard Ferguson
Forest Station
R.R. #4
Kemptville, Ontario
K0G 1J0
(613)258–8355

KIRKWOOD
P.O. Box 310
Bare Root Building
Thessalon, Ontario
P0R 1L0
(705)842–3634

MIDHURST
Midhurst, Ontario
L0L 1X0
(705)728–2900

ORONO
P.O. Box 119
Orono, Ontario
L0B 1M0
(416)983–9147

ST. WILLIAMS
R.R. #1
St. Williams, Ontario
N0E 1P0
(519)586–3576

SWASTIKA
P.O. Box 129
Swastika, Ontario
P0K 1T0
(705)567–3372

THUNDER BAY
Thunder Bay Forest Stn.
R.R. 1
Thunder Bay, Ontario
P7C 4T9
(807)939–2558

WABIGOON
P.O. Box 90
Wabigoon, Ontario
P0V 2W0
(807)938–6376

Private Nurseries

There are numerous private growers located in Ontario. A listing of these growers is contained in the Woody Plant Source List, available for a fee from:

CANADIAN NURSERY TRADES ASSOCIATION
1293 Matheson Blvd.
Mississauga, Ontario
L4W 1R1
(416)629–1184

Appendix 3
Characteristics Of Tree Species Recommended For Rehabilitation

The following table provides more information for the 23 tree species recommended for rehabilitation. It should be used in conjunction with Part 3, Step One, guidelines to species selection.

The table has been based upon both literature review and field experience. Many of the 23 species selected are readily available commercially as seedlings. They are;

Jack Pine
Red Pine
Eastern White Pine
White Spruce
Black Spruce
Norway Spruce
Tamarack
European Larch
Red Oak
Eastern White Cedar
Black Locust
White Ash
Silver Maple, and
Red Maple.

The remaining nine species were selected because their characteristics and common habitat suggest they would tolerate conditions on most pit and quarry sites, while also providing forest products. In the case of Black Locust, its commercial importance is secondary to its soil improving abilities.

A number of abbreviations have been used in the tables. Each is briefly defined.

FOREST REGION

The accompanying map (Figure 16) illustrates the three main forest regions of concern.

B – Boreal

The boreal forest occupies much of northern Ontario. It occurs north of the Great Lakes – St. Lawrence Region and is dominated by coniferous tree species. Lands north of Dryden, Wawa and Kirkland Lake are considered boreal.

G – Great Lakes – St. Lawrence

This region occurs south of the boreal area and north of the line extending approximately from Goderich to Cambridge to Kingston. A mix of northern and southern tree species dominate this region.

D – Deciduous

This is the smallest of the three regions. It occurs south of the Great Lakes – St. Lawrence region and is dominated by deciduous tree species.

FERTILITY

A relative scale has been assigned using L, M, H (low medium and high) designations.

GROWTH RATE

Again, a relative scale has been used. It uses the abbreviations S, M, and R standing for slow, moderate, rapid.

TABLE 11. CHARACTERISTICS OF TREE SPECIES RECOMMENDED FOR REHABILITATION.

Species									
Common Name	Scientific Name	Forest Region	Habitat	Fertility Requirement	Form	Growth Rate	Timber or Specialty	Products/ Importance	Comments
Jack Pine	*Pinus banksiana*	B	– can tolerate very dry, sandy soils – best growth on well–drained, loamy sands	L	– on poor sites form is twisted and short – better form on rich sites – to 15 m height	M	timber	– construction materials – pulp – railway ties, poles	
Red Pine	*P. resinosa*	B,G	– range of soil conditions including sandy and gravelly sites – doesn't tolerate harsh sites as well as Jack Pine	L–M	– straight, limbless trunk – oval crown – to 25 m height	M	timber	– structural timber – poles, piling, railway ties	
Eastern White Pine	*P. strobus*	B,G,D	– wide range of soils – prefers moist sandy or loamy soils – generally poorer growth on clayey or poorly drained sites	M	– straight stem lined with wide–spreading branches – to 35 m height	M	timber	– fine carpentry material – furniture	most valuable softwood in eastern Canada
Pitch Pine	*P. rigida*	D	– shallow sandy or gravelly soils – also on rocky ridges – best growth on well–drained sandy loams	L	– variable – poor form on less fertile sites – better form on rich sites – to 15 m height	M	specialty	– very limited use – scrubby form at northern edge of species distribution in Ontario	
White Spruce	*Picea glauca*	B,G	– wide range of soils – exacting nutrient requirements – best growth on moist, sandy clay loams	M	– uniform conical crown – branches extend to ground – long tapering trunk	S	timber	– very important pulpwood and lumber species	
Black Spruce	*P. mariana*	B,G	– on a range of sites – grows well on deep, organic soils – also present on well–drained slopes and flats – grows best on those moist to wet clay slopes	M	– straight trunk with little taper – narrow, small crown	S	timber	– very important pulpwood species	best–suited to poorly–drained pit, quarry floors where fill material is unavailable to improve drainage
Norway Spruce	*P. abies*	G,D	– prefers moist loams	M	– large tree with long drooping branches	M	specialty	– limited importance	non–native species

Note: See text for abbreviations. Materials for this table were drawn from the following sources: Fowells, 1975; Hosie, 1979; OMNR, 1977.

TABLE 11. CONTINUED.

Species									
Common Name	Scientific Name	Forest Region	Habitat	Fertility Requirement	Form	Growth Rate	Timber or Specialty	Products/ Importance	Comments
Tamarack	*Larix laricina*	B,G	– cold, wet, poorly drained sites – best growth on moist, well–drained, light soils	M	– straight trunk, little taper – to 20 m in height	M	timber	– railway ties, poles, posts, pulpwood	best–suited to poorly drained pit, quarry floors where fill material is unavailable to improve drainage
European Larch	*L. decidua*	G,D	– can tolerate drier sites than Tamarack	L	– similar to Tarmarack	R	timber	– poles, pulpwood	non–native species
Red Oak	*Quercus rubra*	G,D	– rocky or gravelly uplands – better growth on deep loams with adequate moisture	M–H	– straight trunk, free of branches until mid–point – up to 20 m height	S	timber	– furniture, flooring and finishing material	
Black Oak	*Q. velutina*	D	– dry, sandy or rocky ridges	L	– similar to Red Oak up to 20 m height	M	timber	– same as Red Oak	
Chinquapin Oak	*Q. muehlenbergii*	D	– dry rocky ridges, especially on limestone soils	L	– straight tapering trunk – crown narrow with a flattened top – up to 20 m height	M	timber	– furniture, interior finishing, boat–building	
Chestnut Oak	*Q. prinus*	D	– dry, stony, limestone ridges	L	– similar to Chinquapin Oak – up to 10 m height	S	timber	– furniture	
Eastern White Cedar	*Thuja occidentalis*	B,G,D	– variety of sites including swamps and uplands – best growth on moist, well–drained clays and gravelly sites	M	– narrow conical, columnar crown – up to 15 m	S	specialty	– posts, poles	
Eastern Red Cedar	*Juniperus virginiana*	G,D	– gravelly ridges and sandy soils – best growth on sandy loams of limestone origin	L–M	narrowly pyramidal or columnar shape – dense crown of short slender branches	S	specialty	– cedar chests, pencils, carving, ornamental work	

Note: See text for abbreviations. Materials for this table were drawn from the following sources: Fowells, 1975; Hosie, 1979; OMNR, 1977.

TABLE 11. CONTINUED.

Species									
Common Name	**Scientific Name**	**Forest Region**	**Habitat**	**Fertility Requirement**	**Form**	**Growth Rate**	**Timber or Specialty**	**Products/ Importance**	**Comments**
Black Locust	*Robinia pseudoacacia*	G,D	– wide range of soils best on limestone soils – can tolerate lack of subsoil	L	– relatively straight stem branches towards base – up to 20 m height	M	specialty	– fenceposts	important role as nitrogen–fixer and soil improver
Trembling Aspen	*Populus tremuloides*	B,G,D	– best on well–drained, moist, sandy or gravelly loams – grows on sandy sites and those with shallow soils	M	– long cylindrical trunk and short, rounded crown – up to 20 m height	R	timber	– important pulpwood species – also veneer and plywood	regarded as a soil–improving species
White Birch	*Betula papyrifera*	B,G,D	– best growth on moist, well–drained sandy or silty loams	M	– slender trunk with narrowly oval, open crown – up to 25 m height	M–R	specialty	– veneer	
Pin Cherry	*Prunus pensylvanica*	B,G,D	– tolerates dry, sandy sites	L	– short trunk, branching low to the ground – narrow round–topped crown – up to 15 m	M	specialty	– nurse crop for conifer seedlings – fuelwood	
Pignut Hickory	*Carya glabra*	D	– dry ridges and hillsides with well–drained soils	L	– very variable – trunk without much taper – crown a short irregular cylinder – up to 15 m	M	specialty	– sporting goods and tool handles	
White Ash	*Fraxinus americana*	G,D	– best growth on deep, well–drained soil – demands ideal conditions	H	– slender tree; long, clean trunk – up to 20 m height	M	timber	– sawlogs, veneer logs, sporting goods, tool handles	demands high nitrogen and moderate to high calcium
Silver Maple	*Acer saccharinum*	G,D	– best growth on well–drained floodplain sites – rich, moist bottom lands	M	– short trunk which divides into limbs close to the ground – broad rounded crown – up to 25 m height	R	timber	– pulpwood, furniture, flooring	
Red Maple	*Acer rubrum*	G,D	– best on well–drained, moist sites – also occurs on drier ridges	M–H	– trunk divides near ground – short narrow crown – up to 15 m height	M	timber	– furniture – veneer, plywood	

Note: See text for abbreviations. Materials for this table were drawn from the following sources: Fowells, 1975; Hosie, 1979; OMNR, 1977.

Figure 16. Major forest regions (after Hosie, 1979).

Appendix 4
Ministry Of Natural Resources District Offices

ALGONGUIN PARK
P.O. Box 219
Whitney
K0J 2M0
(613)637–2780

ATIKOKAN
108 Saturn Avenue
Atikokan
P0T 1C0
(807)597–6971

AYLMER
353 Talbot St. West
Aylmer
N5H 2S8
(519)773–9241

BANCROFT
Highway 28
Bancroft
K0L 1C0
(613)332–3940

BLIND RIVER
62 Queen Street
Blind River
P0R 1B0
(705)356–2234

BRACEBRIDGE
P.O. Box 1138
Bracebridge
P0B 1C0
(705)645–8747

BROCKVILLE
Oxford Avenue
Brockville
K6V 5Y8
(613)342–8524

CAMBRIDGE
Beaverdale Road
Cambridge
N3C 2W1
(519) 658–9355

CARLETON PLACE
10 Findlay Avenue
Carleton Place
K7C 3Z6
(613)257–5735

CHAPLEAU
190–192 Cherry Street
Chapleau
P0M 1K0
(705)864–1710

CHATHAM
435 Grand Ave. West
Chatham
N7M 5L8
(519)354–7340

COCHRANE
2 Third Avenue
Cochrane
P0L 1C0
(705)272–4365

CORNWALL
113 Amelia Street
Cornwall
K6H 5V7
(613)933–1774

DRYDEN
479 Government Road
Dryden
P8N 2Z4
(807)223–3341

ESPANOLA
148 Fleming Street
Espanola
P0P 1C0
(705) 869–1330

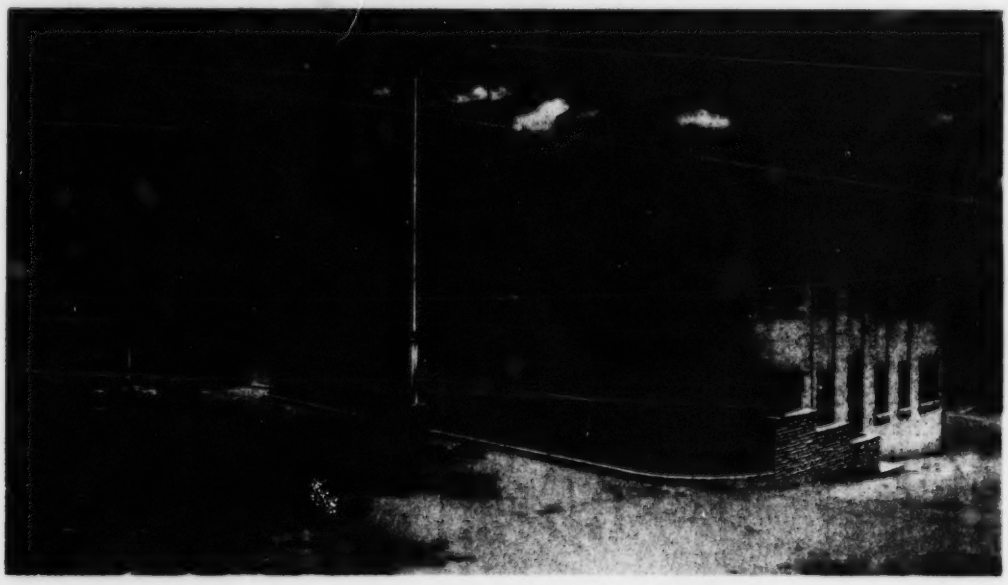
FORT FRANCES
922 Scott Street
Fort Frances
P9A 1J4
(807)274–5337

GERALDTON
208 Beamish Ave. West
Geraldton
P0T 1M0
(807)854–1030

GOGAMA
Low Avenue
Gogama
P0M 1W0
(705)894–2000

HEARST
631 Front Street
Hearst
P0L 1N0
(705)362–4346

HURONIA
Midhurst
L0L 1X0
(705)728–2900



IGNACE
Highway 599
Ignace
P0T 1T0
(807)934–2233

KAPUSKASING
6–8–10 Government Road
Kapuskasing
P5N 2W4
(705)335–6191

KENORA
808 Robertson Street
Kenora
P9N 1X9
(807)468–9841

KIRKLAND LAKE
P.O. Box 129
Swastika
P0K 1T0
(705)642–3222

LINDSAY
322 Kent St. West
Lindsay
K9V 4T7
(705)324–6121

MAPLE
10401 Dufferin Street
Maple
L0J 1E0
(416)832–2761

MINDEN
Minden
K0M 2K0
(705)286–1521

MOOSONEE
Revillion Road
Moosonee
P0L 1Y0
(705)336–2987

NAPANEE
1 Richmond Boulevard
Napanee
K7R 3S3
(613)354–2173

NIAGARA
Highway 20
Fonthill
L0S 1E0
(416)892–2656

NIPIGON
Highway 17
Nipigon
P0T 2J0
(807)887–2120

NORTH BAY
R.R. 3
Hwy. 63
P1B 8K7
(705)474–5550

OWEN SOUND
611 Ninth Ave. East
Owen Sound
N4K 3E4
(519)376–3860

PARRY SOUND
4 Miller Street
Parry Sound
P2A 1S8
(705)746–4201

PEMBROKE
Riverside Drive
Pembroke
K8A 6X4
(613)732–3661

RED LAKE
Highway 105
Red Lake
P0V 2M0
(807)727–2253

SAULT STE. MARIE
875 Queen St. East
Sault Ste. Marie
P6A 5L5
(705)949–1231

SIMCOE
548 Queensway West
Simcoe
N3Y 4T2
(519)426–7650

SIOUX LOOKOUT
Prince Street
Sioux Lookout
P0V 2T0
(807)737–1140

SUDBURY
P.O. Box 3500
Sta. A
Sudbury
P3A 4S2
(705)522–7823

TEMAGAMI
Lakeshore Drive
Temagami
P0H 2H0
(705)569–3622

TERRACE BAY
P.O. Box 280
Terrace Bay
P0T 2W0
(807)825–3205

THUNDER BAY
435 James St. South
Thunder Bay
P7E 6E3
(807)475–1471

TIMMINS
896 Riverside Drive
Timmins
P4N 3W2
(705)267–7951

TWEED
23 Spring Street
Tweed
K0K 3J0
(613)478–2330

WAWA
Highway 101
Wawa
P0S 1K0
(705)856–2396

WINGHAM
R.R. 5
Wingham
N0G 2W0
(519)357–3131

Appendix 5
Conservation Authority Offices

AUSABLE BAYFIELD, C.A.
Box 2410
175 Thames Road West
Exeter
N0M 1S0
(519) 235–2610

CATARAQUI REGION, C.A.
P.O. Box 160
R.R. #1
Glenburnie
K0H 1S0
(613)546–4228

CATFISH CREEK, C.A.
R.R. #5
Aylmer
N5H 2R4
(519)773–9605

CENTRAL LAKE ONTARIO, C.A.
100 Whiting Avenue
Oshawa
L1H 3T3
(416)579–0411

CREDIT VALLEY, C.A.
Meadowvale
L03 1K0
(416)451–1615

CROWE VALLEY, C.A.
Box 416
Marmora
K0K 2M0
(613)472–3137

ESSEX REGION, C.A.
360 Fairview Avenue West
Essex
N8M 1Y6
(519)776–5209

GANARASKA REGION, C.A..
Box 328
Port Hope
L1A 3W4
(416)885–8173

GRAND RIVER, C.A.
Box 729
400 Clyde Road
Cambridge
N1R 5W6
(519)621–2761

GREY SAUBLE, C.A.
R.R. #4
Inglis Falls Road
Owen Sound
N4K 5N6
(519)376–3076

HALTON REGION, C.A.
P.O. Box 1097
Station "B"
Burlington, Ontario
L7P 3S9
(416)878–4131

HAMILTON REGION, C.A.
Box 7099
838 Mineral Springs Road
Ancaster
L9G 3L3
(416)525–2181

KAWARTHA REGION, C.A.
Box 819
Fenelon Falls
K0M 1N0
(705)887–3112

KETTLE CREEK, C.A.
R.R. #8
St. Thomas
N5P 3T3
(519)631–1270

LAKEHEAD REGION, C.A.
Box 3476
Thunder Bay
P7B 5J9
(807)344–5857

LAKE SIMCOE REGION, C.A.
Box 282, 120 Bayview Ave.
Newmarket, Ontario
L3Y 4X1
(416) 895–1281

LONG POINT REGION, C.A.
Box 525
Simcoe
N3Y 4N5
(519)426–4623

LOWER THAMES VALLEY, C.A.
100 Thames Street
Chatham
N7L 2Y8
(519)354–7310

LOWER TRENT REGION, C.A.
441 Front Street
Trenton
K8V 6C1
(613)394–4829

MAITLAND VALLEY, C.A.
P.O. Box 127
Wroxeter
N0G 2X0
(519)335–3557

MATTAGAMI REGION, C.A.
133 Cedar Street South
Timmins
P4N 2G9
(705)264–5309

METROPOLITAN TORONTO AND REGION, C.A.
5 Shoreham Drive
Downsview
M3N 1S4
(416)661–6600

MISSISSIPPI VALLEY, C.A.
Box 268
Lanark
K0G 1K0
(613)259–2421

MOIRA RIVER, C.A
217 North Front Street
Belleville
K8P 3C3
(613)968–3434

NAPANEE REGION, C.A.
25 Ontario Street West
Napanee
K7R 3S6
(613)354–3312

NIAGARA PENNINSULA, C.A.
Centre Street
Allanburg
L0S 1A0
(416)227–1013

NICKEL DISTRICT, C.A.
West Tower, Civic Square
200 Brady Street
Sudbury
P3E 5K3
(705)674–5249

NORTH BAY–MATTAWA, C.A.
P.O. Box 1215,
348 Fraser Street
North Bay
P1B 8K4
(705)474–5420

NOTTAWASAGA VALLEY, C.A.
R.R. #1
Angus
L0M 1B0
(705)424–1479

OTONABEE REGION, C.A.
211 Hunter St. East
Peterborough
K9H 7B5
(705)745–5791

PRINCE EDWARD REGION, C.A.
Box 310
Picton
K0K 2T0
(613)476–7408

RAISIN REGION, C.A.
Box 10
Martintown
K0C 1S0
(613)528–4584

RIDEAU VALLEY, C.A.
Box 599
Mill Street
Manotick
K0A 2N0
(613)692–3571

SAUGEEN VALLEY, C.A.
R.R. #1
Hanover
N4N 3B8
(519)364–1255

SAULT STE. MARIE REGION, C.A.
99 Foster Drive
Civic Centre
Sault Ste. Marie
P6A 5X6
(705)759–5342

SOUTH NATION RIVER, C.A.
Box 69
Berwick
K0C 1G0
(613)984–2400

ST. CLAIR REGION, C.A.
205 Mill Pond Crescent
Strathroy
N7G 3P9
(519) 245–3710

UPPER THAMES RIVER, C.A.
P.O. Box 6278
Station "D"
London
N5W 5S1
(519)451–2800

Appendix 6
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